TITLE: Airspace Surveillance for Air Battle Management

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Introduction

Winning the air battle will be crucial in any future military campaign. Gaining the ability to use the air to our own ends, while denying its use to the enemy, requires adequate weapons, command and control (C2), communication and information systems (CIS) and sensors. In particular, air defence requires the support of airspace surveillance sensors – which is the topic of this paper.

This paper focuses on the future requirements for airspace surveillance (to support the management of the air battle), some of the options for future surveillance sensors and how they contribute to meeting the requirement.

Scope

The paper is concerned with the airspace surveillance required to support the management of the air battle, or in other words the Recognised Air Picture (RAP).

The paper addresses the airspace surveillance required to support future warfighting and non-warfighting missions (not just air defence), the limitations of current sensor types and the technical sensor based options to meet the future requirement. This has allowed the identification of a number of emerging capability gaps and the potential approaches available for filling these gaps.

The paper addresses ongoing developments in operational doctrine and threat. In particular, the development of manoeuvre warfare doctrine, the impact of stealth technology and the proliferation of attack helicopters (AH), unmanned air vehicles (UAVs), and cruise and stand-off missiles.

The paper does not address the surveillance required to support ballistic missile defence, ground based air defence, maritime anti-air warfare or the sensors on board combat aircraft. However, it recognises the influence of these other areas on the overall sensor mix.

The final decision on any future sensor mix will need to take into account a wide range of factors over and above simple sensor performance.

Context

Strategic context

Since the collapse of the Berlin Wall and the birth of the ‘New World Order’, NATO planning and the planning of individual NATO nations has shifted from being based primarily on fighting World War III to planning for a range of operations. These include:

- Article V operations (though of considerably more limited scope than in the Cold War);
- major regional contingencies (e.g. the Gulf War);
- peace enforcement (e.g. Kosovo);
- peace support (e.g. Bosnia);
- support to the civil power (e.g. Northern Ireland, in the case of the UK);
- disaster relief (e.g. after hurricane Mitch or the recent typhoon in Mozambique).

Paper presented at the RTO SCI Symposium on "System Concepts for Integrated Air Defense of Multinational Mobile Crisis Reaction Forces", held in Valencia, Spain, 22-24 May 2000, and published in RTO MP-063.

The impact of this change has been particularly large on UK Air Defence forces. In the Cold War, the UK Ministry of Defence procured many systems specifically for the air defence of the UK. Now, however, the procurement of (almost) all air defence systems must be based on their capability to be deployed to and used within a non-UK theatre of operations.

There is not likely to be a requirement for an air defence capability in all of the above operations. For example, it is unlikely that there will be any need for air defence when repairing the damage done by a hurricane, earthquake or flood. Therefore, if there is no air threat then there is no need for an air defence capability (and little need for a RAP). Therefore, the range of operations which need to be considered in the context of this symposium run from those involving peace support and the policing of no-fly zones to limited wars and regional contingencies.

Operational context

Within the range of possible operations and campaigns there are a number of typical situations, or scenarios, within which the air defence system will need to operate. These are as follows:

- regional conflict in which the multinational force deploys in response to an aggressor attacking another, possibly NATO, country. This has two sub-cases: in the first, the multinational force deploys unopposed and begins military operations at a time of their choosing (e.g. the Gulf War); in the second, the multinational force is attacked/opposed during deployment (e.g. the Korean War).
- regional tension in which the multinational force deploys in response to posturing/threatening activity.
- late phase of a regional conflict in which multinational ground forces have advanced into enemy territory (possibly to regain territory captured earlier) (e.g. the Gulf War).
- operations other than war (also known as combined diplomatic military operations) including peacekeeping, peace enforcement, the enforcement of no-fly zones and service protected evacuations.

Many of the above scenarios are broadly similar to those for which NATO nations have been planning for many years in that they are primarily combat operations. However, the last set (operations other than war) are different and of growing importance. Therefore, it is worth considering these operations and the role of multinational forces within them.

Peace support operations

The end of the 'Cold War' removed the threat of the imminent outbreak of World War III and of a massive direct threat to NATO countries. It also allowed the UN Security Council to take a more active role in world affairs; no longer do the permanent members of the Security Council (USA, USSR, UK, France and China) almost automatically block resolutions with their veto.

However, the 'Cold War' had given a misleading impression of stability in a number of areas of the world. It had suppressed underlying tensions and the risk of nuclear war had obscured the emerging security threats. Thus, since the ending of the Cold War, many ethnic, territorial, religious and other differences have flared into conflict.

With a Security Council more prepared to sanction operations, to settle these conflicts and maintain international stability, the demands on the world's military and civil organisations has increased. Thus, the NATO nation's Armed Forces find themselves involved in these operations. Peace support is a particularly good example of how the demands on the military have changed.

During the 'Cold War', if the UN sanctioned a peace support mission the peacekeepers followed the Scandinavian model. They (military and civil) were neutral, used minimum force, acted with the consent of all parties and without enforcement powers. They froze the conflict and used political means to obtain a settlement. The permanent members of the Security Council were not involved in these operations. (The two exceptions are France, UNIFIL mission in the Lebanon, and the UK, UNICYP in Cyprus.) The permanent members were, in general, perceived as biased and the focus of their military was on countering security risks from their super-power opponents.

Post 'Cold War', the UN Security Council has become more active in addressing threats to international stability. They are now prepared to sanction not just peacekeeping operations but peace enforcement operations. Operations in support of peace now range from the traditional through to the military enforcement of peace. Also, the permanent members of Security Council are active in peace operations.

Peacekeeping: Peacekeeping operations are undertaken under Chapter VI of the UN Charter or sanctioned by the Organisation on Security and Co-operation in Europe. They have the consent of all the major parties to a conflict, to monitor and facilitate the implementation of a peace agreement.

Peace enforcement: Enforcement operations can only be undertaken under Chapter VII of the UN Charter. They are coercive and may lack entirely the consent of the parties to the conflict. The aim is to establish peace or enforce the UN mandate.

The aim of peace operations (keeping and enforcement) is to create a stable environment where all parties to the conflict can move towards a consensual agreement. This agreement is normally built over a long period. It requires delicate skill to build and an appreciation of the impact of all operations, especially forceful action, on the belligerent parties, the media and support for the operation.

Peace support operations can largely be characterised by the degree of consent and violence. Within humanitarian operations, the parties receiving the aid generally want the military to be involved and any violence is likely to be small scale and localised e.g. riot control and banditry. Peace enforcers, acting without consent, may encounter organised military resistance, although this will tend to be in dispersed geographical pockets. Kosovo provides a recent example of large scale, and geographically extensive, organised military resistance to peace enforcement.

It is possible for peace support operations to degenerate. Peace enforcement can become full-blown conflict for a variety of reasons, including the peace enforcers becoming partial, or perceived to be partial, to one side. Similarly, it is possible for peacekeeping operations to degenerate into peace enforcement.

The emphasis in these operations is on:

- *Reassuranc*e, to restore the belligerents' confidence in every parties peaceful intentions, by dispelling apprehensions and confirming positive opinions and impressions. For example, demonstrating the peacekeeping force's impartiality and commitment to peace, and providing information on other parties' passive stance.
- *Support*, to strengthen the belligerents' domestic infrastructure, provide aid and give help and corroboration. Humanitarian operations are principally support.
- *Deterrence*, to dissuade the belligerents from actions that obstruct peace, by persuading them the cost outweighs any potential gains. This supports diplomatic activity to avert conflict and is based on the peacekeepers' evident capability, readiness to use that capability, sense of purpose and resolve. It is also based on the belligerents' values and the inference they draw from any action or counter-action. Deterrence can be:
  - *Implicit* - the demonstrated ability of being able to watch the belligerents' activities and therefore to respond, or
  - *Explicit* - the proven ability to exact rapid retribution that will inflict unacceptable damage to the belligerents' values.
- *Coercion*, to compel the belligerents, with force, to follow a course of action. The force is applied to meet a political rather than a military objective, but at the risk of escalating the conflict. The use of coercion must be carefully and deliberately considered.

Tactical context

The air defence system must have the capability to deal with all types of air vehicle, of any allegiance, including:

- fighter and fighter bomber aircraft;
- high value air assets (HVAA), such as tankers and airborne early warning (AEW) aircraft;
- civil aircraft;
- cruise or stand-off missiles;
- helicopters;
- unmanned air vehicles (UAVs);
- tactical ballistic missiles.

Fighter and fighter bomber aircraft are the traditional targets on which surveillance information is required. There is still a need for surveillance of these targets, for example when supporting a no-fly zone, engaged in symmetric[1] warfare with a capable opponent or constrained by rules of engagement (ROE) from attacking enemy airbases.

High value air assets (HVAA) and civil airliners are large targets that fly at, relatively, high altitudes, so are generally easy targets for the sensors to survey. Thus they are not key drivers of the sensor mix, unless considering the vital task of identification.

Cruise and stand-off missile proliferation represents an emerging threat to multinational operations. These weapons (using, for example, combined GPS and inertial navigation) are able to hit targets of known location (e.g. infrastructure targets) with only minimal support from reconnaissance, intelligence or surveillance assets[2]. This makes them attractive to less sophisticated adversaries and those who would expect to have to engage in asymmetric warfare with a Western coalition. In particular, they could pose a significant danger to the ports and airbases that are vital for multinational forces entering an operational theatre.

Attack helicopters are increasingly taking over the close air support role and gaining a deep strike role, so their importance as targets that must be detected, tracked, identified and dealt with is rising.

UAVs are becoming more widespread. Most are used in the reconnaissance role, so present a major threat to the ability of our land forces to successfully conduct manoeuvre warfare. Historical analysis has highlighted the importance of preventing enemy air recce, which will be increasingly carried out by UAVs, in achieving success in manoeuvre warfare.

Proliferation of tactical ballistic missiles (TBM) represents a recognised threat to multinational operations. However, this paper does not consider the specific problems associated with TBM surveillance.

Surveillance Requirement

'Can't see, can't fight'

Airspace surveillance means the detection, tracking and identification of air vehicles. To be useful, the surveillance data must be provided to those who need it and in a suitable format (i.e. the airspace surveillance system is tied together with appropriate communications and picture compilation systems in order to support the commander or decision maker).

In terms of the OODA loop, the airspace surveillance system provides observation and supports orientation.

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1 Symmetric warfare applies to conflicts, like World War II or the Iran-Iraq war, where the advantage in a campaign or environment can swing from one side to the other. Asymmetric warfare applies to conflicts like Vietnam or Gulf War where one side continuously dominates an environment, such as the air or sea, and the other side may utilise unconventional methods.

2 Increased support would allow the power of these weapons to be more fully exploited.

General requirement

Surveillance only needs to be good enough to support the required decision or task. It is possible to identify a number of high level tasks which surveillance should support. These tasks include (in warfighting operations):

- Provide picture of enemy/hostile activity: to provide intelligence about posture, etc. (i.e. general situation awareness).
- Warn own forces of the presence/activities of air vehicles: to allow appropriate passive and active defensive measures to be implemented.
- Locate/identify enemy bases/infrastructure and/or supporting forces: to support/allow attack by friendly assets.
- Locate/identify targets in flight: to support/allow attack by friendly assets[3].

In peace support operations the above may be modified and extended to include:

- Provide a picture of all parties' activities: both to reassure and deter.
- Provide proof of activity: for example, to prove to the media or United Nations (UN) security council that an agreement is being broken.

The accuracy, timeliness and completeness of the surveillance required to support each of the above tasks (and the detailed instances of them) will be different for each task (and instance). However, in general, the level of accuracy, timeliness and completeness increases as you move down the above lists.

The key requirement for airspace surveillance is that which relates most directly to air defence and force protection, namely locate/identify targets in flight to support/allow attack by friendly assets. Note that force protection tasks (such as air defence) tend to impose the most rigorous and time critical requirements.

The specific requirement can be different for different types of air vehicles or in different types of conflict. The requirement set also determines how difficult it is to fulfil that requirement (i.e. can it be done and is it affordable).

Specific requirements

When considering the requirement for the surveillance of hostile fighter or fighter bomber aircraft, this can be set in a number of ways and at a number of different levels. For example, the objective can be to provide sufficient surveillance to support the intercept of hostile fighters by friendly fighters that are already airborne and on a combat air patrol (CAP). This would only require surveillance cover extend roughly 50-100 nautical miles in front of the friendly fighters. However, a requirement to be able to support the scrambling of fighters from ground alert in time to allow the intercept of hostile fighters by some predetermined point, leads to a requirement for surveillance cover to extend much further forward in order to provide the increased warning time required.

Similarly, the difficulty of providing a system (and the associated surveillance) to defeat cruise missiles and stand-off missiles depends on the level of requirement. The objective could be to provide:

- Point and local area defence (e.g. key military and infrastructure targets such as HQ, bridges, ports and airfields);
- Area defence (e.g. defend an entire region including civilian population centres);
- Counter weapons of mass destruction (WMD) (e.g. destroy missiles at sufficient range to protect friendly countries and forces – in other words, the destruction of missiles outside friendly territory (and thus often over enemy territory));
- Conventional counter force (e.g. location of launch points with sufficient accuracy and timeliness to support the attack of the launcher).

[3] Including the tracking of air vehicles from their point of origin to support Identification By Origin (IDBO).

Surveillance Problems

The provision of the required surveillance is made difficult due to a number of factors.

Atmosphere and weather

The need for long range surveillance, coupled with the problems of atmospheric absorption and clouds means optical and infra-red systems normally cannot obtain the required ranges: except in certain specialist applications, such as at detection of ballistic missiles and other high altitude targets by high altitude or space based sensors. Thus radar is the primary sensor used to provide the required surveillance, and the following discussion concentrates on radar sensors.

Low level and slow

Targets that fly at low levels (i.e. at a low altitude) cannot be detected at long ranges by microwave ground based radars as they are below the radar horizon.

The need to detect low level targets at long ranges is the primary driver behind airborne early warning systems (such as the E-3). But such airborne systems are looking down to see these low level targets, so are looking for them against a background of clutter. This does not present a major problem when trying to detect a fast moving target as moving target indication (MTI) or doppler processing can be used to detect the target despite the clutter. However, the ability to detect slow moving targets such as helicopters and propeller driven UAVs flying at 60-90 knots will be limited by the clutter.

Stealth

At present only the US is fielding 'stealthy' combat aircraft (i.e. the F117, B2 and F22). The cost of such aircraft is liable to mean that they are very unlikely to be deployed by opponents, other than in very small numbers, before 2020 (at the earliest): compare this with UK plans for FOAS in 2017+. However, it is much more likely that future combat aircraft, and aircraft modification or update programmes, will result in fighter and fighter bomber aircraft becoming a bit more 'stealthy'.

The relatively simple shapes of missiles and their shorter development cycles make the emergence of a 'stealthy' missile threat much more likely. Western nations are planning to field 'stealthy' stand-off missiles around 2000-2005, so the technology to do this is liable to leak or proliferate by 2010-2015.

The potential impact of this is considerable. Consider for example a radar system capable of detecting a target with radar cross section of 1 m^2 at 200 miles (with some given probability of detection etc.). The impact of alternative assumptions about cruise missile radar cross section (RCS) on detection range and surveillance area (assuming circular coverage) is shown in table 1.

RCS		Range (miles)	Area (miles^2)
1 m^2	0 dBsm	200	125,500
0.1 m2	-10 dBsm	112	39,500
0.01 m^2	-20 dBsm	63	12,500
0.001 m^2	-30 dBsm	36	4,000
0.0001 m^2	-40 dBsm	20	1,300
0.00001 m^2	-50 dBsm	11	400

Table 1 - impact of stealth

Clearly 'stealthy' cruise missiles that combine a low RCS, with a low altitude flight path and the capability to hit fixed targets will pose a significant air defence problem.

ECM

Electronic counter measures (ECM), or jamming, can be used to degrade radar performance. Improvements in ECM systems increasing their responsiveness, directivity and choice of signal, coupled with reduced size and potential reductions in cost, may lead to an increase in the threat presented to the surveillance system by ECM.

Identification

Identification consists of two functions: classifying air targets by allegiance (e.g. friend, neutral, hostile) and class/type (e.g. UAV, fighter or F-16C).

The changing nature of the Western way of war (i.e. growth of peace support operations, reduction in perceived public acceptance of casualties (particularly fratricide) and the CNN factor) has led to the Rules of Engagement (ROE) becoming more restrictive. This increases the level of confidence required in the identification of target allegiance: it may also impact on the requirement for type identification as in the future different ROE may apply, for example, to manned and unmanned systems.

The ability to positively identify the allegiance and type of friendly platforms, through use of co-operative techniques (in other words IFF systems and use of data link messages such as the PPLI messages from JTIDS equipped platforms) and procedural methods, is generally good. However, the positive identification of small friendly unmanned systems (such as stand-off missiles and UAVs) may present problems. Other problems may arise from the multinational nature of future operations particularly those involving non-NATO nations, as these nations are less likely to be equipped with fully compatible co-operative identification systems.

At present the identification of the allegiance of hostile platforms relies almost entirely on procedural means, with support from some sensor systems (particularly ESM). Therefore, there is a problem with obtaining positive identification of the allegiance and class/type of hostile (and neutral) air platforms.

Tracking

The current Recognised Air Picture is primarily built up using a number of ‘turn and burn’ microwave radars, which provide target updates at 10-12 second intervals (assuming no missed plots). Thus maintaining tracks during high speed manoeuvring (e.g. combat) is unlikely.

Further, the picture is not built using all the plots produced by these radars, but is created by selecting the best tracks from the set of tracks produced by the individual radars. Thus the overall tracking ability is not greater than the sum of the individual tracking abilities; instead, the best track is selected.

This will lead to problems in the future if there is an increased need for proof of activity in peace support operations. For example, it may become necessary to be able to provide sufficiently continuous and accurate tracking to allow the presentation, perhaps ultimately in an international court of law, of ‘evidence’ of activity. For example, it may be necessary to be able to provide ‘evidence’ that an aircraft took off from a particular location, flew to a target, where it released a weapon, and then returned to its origin. Similarly, it might be necessary to prove that the multinational force shot down the pilot who carried out the attack, rather than his wingman.

Manoeuvre warfare

Operational doctrine is also changing and developing. In particular, there has been a general move away from attritional warfare to manoeuvre warfare. Thus ground combat forces are planning to fight a manoeuvre battle. This may mean that at some stage in a regional conflict they will have advanced deep into enemy territory (possibly to regain territory captured earlier) and in doing so bypassed enemy ground forces. However, there will still be a need to provide air defence of these advance units, which might lead to the need to orbit an E-3 over the bypassed enemy ground forces. This is not ideal as they may still have working SAM systems.

Similarly, there would be value in providing surveillance of enemy airborne air defence forces to the depth at which offensive air systems will operate. This becomes increasingly difficult as the range of offensive air systems increases and the range of defensive missile systems increases, which leads to increased stand-off ranges for AEW aircraft.

Capability Gaps

The above discussion has highlighted the following surveillance problems:

- *surveillance of 'stealthy' cruise missiles and stand-off missiles*;
- *surveillance of helicopters and UAVs;*
- *positive identification of hostile (and neutral) air vehicles;*
- *providing 'evidence' of activity in peace support operations*;
- *surveillance in the face of jamming*;
- *surveillance to support manoeuvre warfare or offensive air.*

The depth and importance of these gaps determines which require the most urgent attention.

Surveillance Options

Deciding what to do about these capability gaps is a complex and highly interconnected problem. Above all, any potential solution must be able to be implemented in the real world, so must be affordable. Thus, it is no use setting too demanding a requirement. In addition, it is necessary to consider a range of other factors over and above simple surveillance capability such as deployability, reliability, vulnerability and critically the need to interoperate with allies and coalition partners.

Setting a goal requires balancing the depth of the gap, how critical the gap is to success and the ease of overcoming the gap.

Technical capabilites

There are a number of future sensor developments or options which may well have an important part to play in overcoming these gaps. A number of the options are discussed below[4].

HF radar. There are three particularly interesting HF radar options:

- The first is the use of HF skywave radar to detect (fixed and rotary wing) aircraft and ships at very long ranges (between 500 km and 3000 km - ignoring any double bounces) by reflecting the radar beam off the ionosphere. HF skywave radar's primary drawback is the very large antenna array required, which severely limits deployability.
- The second is the use of HF surface wave radar, where the radar is sited on a coast so that the radar energy can couple into the salt water. This allows the radar to detect aircraft, and ships, down to sea level at ranges out to roughly 300 km.
- The third is the use of a much smaller HF radar using near vertical incidence scattering from the ionosphere to detect helicopters at ranges of up to 600 km.

VHF/UHF radar. Most stealth is designed to work at microwave frequencies and is thus less effective at longer wavelengths. Also, as wavelengths get longer then target resonance effects are observed which can increase the effective radar cross section of a target. Thus a missile which is 'stealthy' at microwave frequencies may not be 'stealthy' at VHF/UHF frequencies. Therefore, ground based or airborne VHF/UHF

[4] Space based systems may well have a role in the longer term. Such systems would naturally provide the depth of coverage required.

radars are useful as a counter to stealth, and through increasing frequency diversity provide increased resistance to jamming.

Microwave radars. There are a number of options available for improving the performance of microwave radars including:

- Use of E-scan radars (also known as active phased array radars) where the ability to electronically change the beam shape and pulse characteristics in a flexible and responsive manner means that 'stealthy' targets can be more easily detected (using, for example, alert-confirm techniques), tracks can be updated more frequently if required (thus improving tracking accuracy), non co-operative target recognition (NCTR) techniques can be used to positively identify hostile air vehicles, and the radar can search for targets which have been detected by other (perhaps less accurate) sensors.
- Use of bistatic and multistatic techniques as a counter to stealth. Some stealth techniques deliberately reduce the signal scattered directly back towards the transmitter, and increase the signal scattered in other directions. Similarly, most stealth treatments are primarily concerned with reducing the forward sector signature of a target.
- Increased sensor integration. Low level targets (such as cruise missiles, helicopters and some UAVs) may be seen intermittently by a number of sensors (e.g. those associated with ground based air defence (GBAD) systems). If these sensors report their detections/tracks then the overall picture (i.e. RAP) is liable to be significantly improved. Similarly, the integration of the data collected by systems such as JSTARS and ASTOR, which are designed to provide an MTI picture of slow moving ground targets and which may also detect slow moving air targets (such as helicopters and possibly UAVs), would improve the air picture.

Network sensors. There are a number of options that could provide a network sensor capability. Such a network would be intended to provide robust and (very importantly) low cost detection of targets that are otherwise difficult to detect (e.g. cruise missiles, helicopters and UAVs). They may employ a variety of sensor techniques including forward scatter radar (where a target is detected as it flies through a network of low power transmitters and receivers), acoustic sensors, ESM and electro-optic sensors.

Figure 1 provides a simplified view of which of these various sensor options helps to overcome each of three problem areas (stealth, low level targets and ECM).

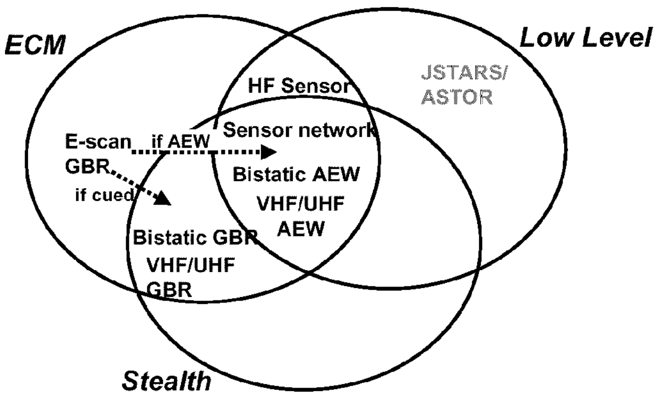

Figure 1 - sensor capability

Figure 1 is in the form of a Venn diagram, with three interlocking problem areas. The sensors are then placed on the diagram to show in which areas they offer improvements in capability. Thus a sensor at the intersection of two areas (e.g. HF sensors) offers improvements in both areas (e.g. low level coverage and jamming (through increased frequency diversity in this case)).

Figure 2 is the same as figure 1 with the addition of a rough representation of tracking accuracy and the ability to provide positive identification. Tracking accuracy is indicated by the size of the text: the larger the text, the more accurate the tracking capability. Identification capability is added round the edge of the diagram.

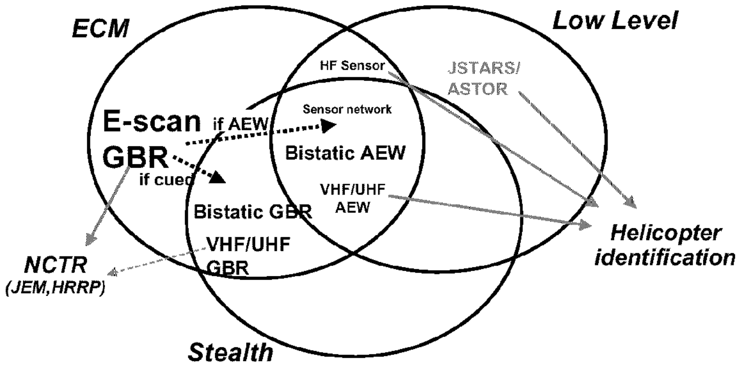

Figure 2 - further sensor capability

Tying the sensors together

The various sensors need to be tied together by an effective communications and picture compilation process in order to provide the information required by the commander. The variety of means available add extra layers of complication, and of options, to the decision making process about what surveillance system we need in the future.

Conclusions

This paper has concentrated on the surveillance required, and capability of the sensors to provide sufficient surveillance, to support future air battle management in both warfighting and non-warfighting operations.

The paper has not addressed the surveillance required by individual weapons systems (such as ships, fighters and SAM systems), but has concentrated on the wider requirements for a Recognised Air Picture. It has not addressed the requirements for Ballistic Missile Defence, as the author does not feel qualified to comment on the specific surveillance difficulties associated with BMD. However, clearly a TBM has a massive launch signature when compared with a cruise missile, flies significantly higher and is physically larger, but timelines are shorter.

The broad look at future requirements has highlighted the following existing, emerging and deepening problems (or capability shortfalls):

- *surveillance of 'stealthy' cruise missiles and stand-off missiles*;
- *surveillance of helicopters and UAVs;*
- *positive identification of hostile air vehicles;*
- *providing 'evidence' of activity in peace support operations*;
- *surveillance in the face of jamming*;
- *surveillance to support offensive air or manoeuvre warfare.*

The quick look at the capability of various radar sensor developments to fill these gaps has identified a range of technical options that can be used to overcome these gaps. However, without a full analysis of all the various factors (not least of which are cost and integration within multinational operations) it is not possible to say what the future mix of airspace surveillance sensors to support air battle management, and support air defence in multinational operations, should be.

Abbreviations:

AEW	Airborne Early Warning
AH	Attack Helicopter
ASTOR	Airborne Stand-Off Radar
ATI	Air Target Identification
BMD	Ballistic Missile Defence
C2	Command and Control
CAP	Combat Air Patrol
CIS	Communication and Information System
CNN	Cable News Network
dBsm	decibel square metres
DERA	Defence Evaluation and Research Agency
E-scan	Electronically scanned (e.g. active phased array radar)
ECM	Electronic Counter Measure
ESM	Electronic Support Measure
FOAS	Future Offensive Air System
GBAD	Ground Based Air Defence
GBR	Ground Based Radar
GPS	Global Positioning System
HF	High Frequency
HQ	Headquarters
HRRP	High Resolution Range Profile
HVAA	High Value Air Asset
IDBO	Identification By Origin
IFF	Identification Friend Foe
JEM	Jet Engine Modulation
JTIDS	Joint Tactical Information Distribution System
MTI	Moving Target Indication
NCTR	Non Co-operative Target Recognition
OODA	Observe Orientate Decide Act
PPLI	Precise Position Location Indicator
RAP	Recognised Air Picture
ROE	Rules of Engagement
RCS	Radar Cross Section
SAM	Surface to Air Missile
TBM	Tactical Ballistic Missile
UAV	Unmanned Air Vehicle
UHF	Ultra High Frequency
VHF	Very High Frequency
WMD	Weapons of Mass Destruction

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